the promised land, the land lying open to the human view, so temptingly since the first man looked up to the sky, but that a few pathways are being mapped out, along which we may direct a hopeful attack. Our problems take a more definite form, and even though we were never to solve them completely, let us remember the words of the poet:

If God held in His right hand all truth, and in His left nothing but the ever ardent desire for truth, even with the condition that I should err forever, and bade me choose, I would bow down to his left, saying, "Oh, Father, give; pure truth can be but for Thee alone."

J. C. KAPTEYN

## BLOOD PARASITES[1]

YOU will remember that Mephistopheles, when he insists upon the bond with Faust being signed with blood, says, "Blut ist ein ganz besondrer Saft" (Blood is a quite special kind of juice). Goethe would probably not have used the word "Saft" had he been writing "Faust" to-day instead of in 1808, for at that time the cellular elements of the blood—although they had been seen and described by Leeuwenhoek in 1686—were believed to be optical illusions, even by so distinguished a person as the professor of medicine of that time at the Sorbonne. The incredulity of scientific men as to what they see is proverbial and astounding, fortunately; but it is probably because science is really quite sure of nothing that it is always advancing.

I have the privilege this evening of trying to show you the barest outlines of our present knowledge of the parasitology of the blood. It is a subject of great practical and economic importance, as many grave diseases of man and beast are caused by these parasites, which, on account of their minuteness, enormous numbers and very complex life-histories, are very difficult to eradicate or to deal with practically. On this account there is a good deal of the enthusiasm of the market-place mixed up with this subject, which, although a new one, has advanced with great rapidity, and has revolutionized pathology and medicine as far as possible. From our point of view it began in 1880 with the discovery by Laveran, in the military hospital of Constantine, of the parasite which causes malaria. This caused the protozoa, to which order most of these parasites belong, to oust bacteria from the proud position they then occupied of being the cause of all the ills we have to bear, and to reign in their stead; not an altogether desirable change; for when you have seen what I shall show you, you will agree with me that sufficient unto life is the evil thereof. It has had all the disadvantages of a new subject, and since that time floods of work have been poured into journals, annals, proceedings, etc., some of it of the best, with much of it that is indifferent, temporary and bad; so that at times it seems as if this branch of science were in danger of being smothered in the dust of its own workshop, or drowned in the waters of its own activity. We do not, nowadays, keep our ideas and scraps of work to ourselves until they are either established, or, as is more likely, dissipated, so we have a huge mass of what is called "literature," filled with many trivial, fragmentary and doubtful generalizations, many of which we have with pain and trouble to sweep into the dustbin: nature's blessed mortmain law taking too long to act. You remember Carlyle complained—to use a mild term—of Poggendorff's "Annalen," and I feel sure that, if he had had to study blood parasites now, he would have said that it was a much over-be-Poggendorffed subject. Blood parasites are afflicted, too, with ter-

[1] Abstract of a lecture before the Royal Institution of Great Britain, May 2, 1913.

rible names, and with large numbers of them; some have as many as ten or even fifteen different names, perhaps on the Socratic principle, that naming saves so much thinking. And they are in Latin, too, so that the terminology of this subject is a perfect museum of long Latin and hybrid-Latin names. The terminology generally of our later biology is, as one has said, "the Scylla's cave which men of science are preparing for themselves, to be able to pounce out upon us from it, and into which we can not enter." This will be my excuse if I should use words you do not understand.

I will just remind you of the structure of the blood, that it consists of an extraordinarily complex fluid—the plasma—which holds in suspension living cellular bodies, called cells or corpuscles. These are of two kinds, red and white corpuscles. The red are by far the more numerous, and in man there are about 5,000,000 of them to a cubic millimeter of blood, but this number varies enormously under the influence of parasites. To these red corpuscles is due the red color of the blood, and they are the carriers of oxygen, acquired by the aeration of the blood in the lungs, to the tissues. We breathe in order that they may breathe, for we only care about oxygen in so far as they care about it.

The other kind of corpuscles are the white, or leucocytes, and of these, in health, there are about 7,500 per cubic millimeter. A few years ago it was enough to know that there were red and white corpuscles, but now we have to know more. Through the work of Ehrlich we know that there are at least five different kinds of leucocytes in normal blood, which I will just indicate to you.

1. *Lymphocytes.*—These are the smallest cells, and contain a relatively very large nucleus.

2. *Large Mononuclears.*—These are large, and are called macrophages, as they possess the power of being able to absorb and digest parasites and other foreign bodies.

3. *Polynuclears.*—These are characterized by the irregular, moniliform aspect of their nucleus, and they are called microphages for the same reason that the large mononuclears are called macrophages. Both of these are also called, generally, phagocytes, on account of their power of ingesting and digesting foreign bodies.

4. *Eosinophiles.*—These are characterized by a bilobed nucleus, and by granulations which color deeply with eosin and other acid colors.

5. *Labrocytes or Mastzellen.*—These are rare, and are characterized by large granulations which stain with basic colors.

In parasitic diseases these corpuscles are profoundly modified and altered, numerically and morphologically, and other new elements may make their appearance in the blood.

The blood is essentially the same in all animals, but it varies within certain limits. For instance, the red corpuscles are not of the same size and shape in every animal, and in birds and fishes they are nucleated; in us they are only nucleated in fœtal life and in disease. The mononuclear and polynuclear leucocytes are really separate organisms living in us, and they have qualities which it is very difficult to call anything else but consciousness; so that it is a subtle distinction to draw the line between the parasites—which these leucocytes are, in a way—which are part of us, and those that are not. When the balance of power is well preserved amongst our leucocytes, when they are working well together, then all is well with us; if we are ill, it is because they are quarreling with themselves or with an invader, and

we send for Sir Almroth Wright to pacify or chastize them with his vaccines.

So that, as Darwin said, "An organic being is a microcosm, a little universe, formed of a host of self-propagating organisms, inconceivably minute and numerous as the stars in heaven"—as we ourselves are but parts of life at large.

The three main functions of blood are: that it is a means of respiration, a means of nutrition and a defense against invading organisms.

And now to these latter. A blood parasite proper is a living being, vegetable or animal, passing part or the whole of its existence in the blood of another living being, upon which it lives, this being obligatory and necessary to its life-cycle.

It was in 1841 that the first blood parasite was seen by Valentin in the blood of a fish, and two years later Gruby gave the name *Trypanosoma* to an organism he found in the blood of a frog. But since Laveran's discovery of the malarial parasite in 1880, we have learned to differentiate many other parasites as causal agents of such diseases as I shall mention later in connection with the various parasites. But we know as yet dangerously little about most of them, so that we have strenuously to resist the temptation to make our account of them sound too harmonious, before we have found half the notes of the chord we are trying to play. We speak, as it were, with authorized uncertainty, and there are parts of our science which, after all, are only expressions for our ignorance of our own ignorance. These parasites have a very complicated life-history; part of their life-cycle is passed in the blood of man or beast, and part in various parts of the body of some blood-sucking invertebrate, such as a fly, mosquito or tick, which transfers the parasite to another animal whilst feeding from him. It was thought formerly that blood parasites would be a restricted order, but the work of recent years has shown that they have an enormous distribution both geographically and as regards their hosts. For instance, during the last five years I have had the opportunity of examining all the animals (in the large sense of the word) which have died in the Zoological Gardens. I have examined the blood of over 8,000 animals, coming from all parts of the world, and I have found parasites in the blood of 587 of them, that is, in about 7 per cent., and in 295 species of animals I have found them for the first time. I mention this just to give you some numerical idea of their occurrence and distribution.

It will be better to take first those parasites which live in the plasma, and then those that live in the corpuscles, rather than to attempt to take them in their, at present rather uncertain, biological order; and I will begin at the bottom, biologically speaking, that is, with the bacteria which are plants. These only require mention, since they do not live in the blood as parasites proper, but only as accidental parasites—that is, parasitism is not necessary to their life-cycle; they get into the blood in the later, or in certain, stages of certain diseases.

An example is the blood of a Senegal turtle-dove which died in twenty-six hours from fowl cholera. This bacillus was discovered by Pasteur, and is interesting, as it was his work upon it which led to his discovery of the attenuation of a virus, and of its transformation thereby into a protective vaccine.

The first parasites proper I shall mention are the spirochetes. These have at present rather an insecure position in our idea of nature; they were formerly classed close to the bacteria, but now they are placed tentatively among animals, and

they are not yet quite sure of their place. But they, nevertheless, although insecure of their place in the books, produce grave diseases, such as relapsing fever, tick fever of man, the spirochetoses of horses, oxen and birds, syphilis and yaws. They, with the exception of the last two, are carried by, and developed in, ticks and bugs; and in tick fever the parasite is also found in the nymph form of the tick, and this is one of the rare instances of heredity of a parasite.

The spirochete of relapsing fever in man was discovered by Obermeier in 1868, and he died from inoculating himself with the blood of a patient with the disease. He was one of the first scientific martyrs; he established our knowledge of the cause of this disease at the expense of his own life.

We will now take a long jump to the filariæ. These are nematode worms, the embryo forms of which live in the blood; the parent forms, being too large to get through the capillaries, live in many other parts of the body. The larval form lives in the body of some invertebrate—in a few known cases in a mosquito, or in a crustacean. The microfilariæ were discovered by Demarquay in 1863. Many of them show a remarkable periodicity, some appearing in the blood at an exact hour at night, and some in the day, for which phenomenon there is at present no satisfactory explanation.

Some are short, and some long, and some are encapsuled, others not. Filariæ cause various diseases, probably elephantiasis, and certainly enormous varicosities of the lymphatics, chyluria, chylous dropsy, Calabar swelling and certain tumors.

We now come to the trypanosomes. They are flagellated organisms, which are the cause of many deadly diseases in men and animals; such as sleeping sickness, nagana (or tsetse-fly disease), surra, mal-de-caderas, dourine and others. They are transferred from animal to animal by biting flies, fleas, lice and leeches, in which the sexual part of their life-cycle takes place. The first one was seen in the blood of a frog by Gluge in 1842.

A type example is *T. Lewisi* in the blood of a rat. This was discovered by Lewis in 1878, and is found in about 25 to 29 per cent. of wild rats. Some die, but most recover and become immune; it is a very specific parasite, and can not be transferred to any other kind of animal.

The *T. Brucei,* causing nagana or tsetse-fly disease, probably exists in the wild game of South Africa, much as the *T. Lewisi* does in the wild rats, but when it is carried by the tsetse-fly to domesticated animals it kills them one and all in enormous numbers.

The *T. Gambiense,* which causes sleeping sickness, was first seen by Dutton in 1902, and is carried by another species of tsetse-fly.

Nature attempts to fight against these invaders by phagocytosis. The parasites, however, multiply so rapidly that this method of attack is not very effectual; it can only be so in very early infections, and probably it then often is, that is, before the parasite has had time to start dividing. At the present time the question of trypanosomosis amongst man and animals is, for many countries which have colonies, of the greatest economic importance, so that a great deal of work has been done in the attempt to find a cure. A great many drugs, new and old, have been tried, and some good has been done. The first drug which was found to be of service was arsenic, first in simple and then in complex combination, and the sub-committee of the Royal Society, formed for the purpose of supervising experiments in this direction, suggested the trial of antimony in these

diseases, on account of its near chemical relationship to arsenic.

This has given better results than arsenic, and a commission is at present at work in Africa, in the Lado district, trying its effects on a large scale. We found that the salts of antimony were too rapidly eliminated from the body to be successful in the larger animals and man, and so we devised a very finely divided form of the metal itself which we put directly into the circulation, and this has given, so far, the best results. The leucocytes eat it up and transform it slowly into some soluble form, taking, in a horse, for instance, four days to dispose of one dose, and the effect of this is much more profound and lasting than that of the salts. But some trypanosomes always escape, since one dose is never sufficient for cure. In rats with nagana, in which the trypanosomes by the fifth or sixth day may number 3,000,000 per cubic millimeter of blood, the minimum number of doses for cure has been found to be four, and with this dosage it is possible to cure 100 per cent. of rats. So there is still some hope.

It is interesting in this connection to remember what Bacon, whose death, you know, was due to an experiment he undertook to prove the preservative action of intense cold upon animal bodies, says, "Laying aside, therefore, all fantastic notions concerning them, I fully believe, that if something could be infused in very small portions into the whole substance of blood . . . it would stop not only all putrefaction, but arefaction likewise, and be very effectual in prolonging life." His vision was prophetic!

The bird trypanosomes are very much larger than the mammalian variety, are very dense and move much more slowly.

An example of an organism very closely allied to the trypanosomes which is only found in fishes' blood, and is called a *Trypanoplasma,* has two flagella, and the micro-nucleus is very large. They are probably transferred by leeches, but very little is yet known of them.

There are other flagellated organisms which may appear in the blood and live there as accidental parasites. There is a kind of inflammation of the intestines in reptiles (in the large sense) which causes the mucosa of the intestine to become permeable, so that some of the organisms which live in the intestine are able to get into the blood and live there. The only mention of these organisms in the blood is by Danilewsky, who in 1889 found hexamitus in the blood of a frog and tortoise. When in the blood they appear to excite a general œdema and ascites. I have found them now in nine cases. These are interesting as showing the power of adaptation to new surroundings possessed by these parasites.

I now come to the intracellular parasites. Schaudinn thought that the bird trypanosomes had an intracellular stage, and if this were so they would form a bridge between the extracellular parasites, of which I have shown you types, and the intracellular parasites we are about to consider. But Schaudinn seemed, with his very brilliant attainments, to want a little more ballast of medical earth-knowledge. His work on this point has not been confirmed, and he was probably misled by a double, or even treble infection, so that we must think of these intracellular parasites as quite distinct from the others.

I will take first the *Plasmodium præcox,* the cause of the malaria in birds, as this parasite is of great historical interest; for it was Ross's work on this organism and his discovery of the rest of its life-cycle in the mosquito, which enabled him—on account of the great likeness between this and the parasite causing human malaria—to

deduce from the one the etiology of the other, which was confirmed by Grassi and others. The *Plasmodium prœcox* is, in many stages, so like human malaria that it can only be differentiated by the presence of the oval nucleus of the bird's red corpuscles. The life-cycle is very complex, part taking place in the blood of the bird, and another part (sexual reproduction) in the body of a mosquito. This parasite was first seen by Grassi in 1890; it is very widely distributed, and is very deadly to birds.

Human malaria has been known for centuries. Varro, who knew a good deal about what we should now call hygiene, more than a century B.C., thought that malarial fevers were due to invisible animals, which entered the body with the air in breathing, and Vitruvius, Columellus and Paladius were of the same opinion. Now we know that the mosquito is again the carrier, and that the sexual part of the parasite's cycle takes place in it, but whether the mosquito alone can account for all the phenomena of malaria is not yet quite certain.

There are three varieties of malaria in man—the tertian, quartan, and quotidian; in the tertian the cycle of the parasite in the body takes forty-eight hours, and in quartan seventy-two hours, and in pernicious malaria the fever is very irregular, but continuous. Whether there are three different parasites, or only one, which is altered according to its environment of host, climate, etc., is still apparently uncertain. Laveran and Metchnikoff believe in the specific unity of the parasite, whereas some observers want as many as five different species.

Just as in human malaria the pernicious form is distinguished by the elongated form of its gametes, so in birds there is a parasite which is distinguished, in the same way, from *Plasmodium prœcox* by its very elongated gametes. This parasite is called *Hœmoproteus Danilewski.* Its development is unknown; it begins as a tiny irregular body in the red corpuscles of the bird, then it grows in the long axis of the cell and turns round the end of the nucleus. It is possible in these parasites to follow the process of impregnation, which normally takes place in some insect. By taking the blood when full of the long, fully-grown gametocytes, and keeping it for a time outside the body, this process can be followed.

First of all, the gametocytes escape from the blood-corpuscles and roll themselves up into a ball. Some of these remain quiet—the females, curiously, the macrogametocytes—whilst in the microgametocytes active movements are seen; then tailed processes are seen projecting from its surface, which at last get free and wander about in the blood, this constituting the origin of the microgametes from the microgametocyte. They then find a macrogamete, and penetrate into it and fertilize it. This fertilized macrogamete then alters its shape and becomes an ookinete, with the remains attached containing the pigment. It may enter a red corpuscle, but it usually breaks up, because it finds it is not in the stomach of the insect it intended to be in, but between two pieces of glass.

From *Hœmoproteus* it is easy to pass to a rare and undetermined parasite of the blood of birds called a *Leucocytozoon.* It occurs in the blood in the form of a long, spindle-shaped, unpigmented body. Very little is known of it except that it is found in its sexual forms. The earliest observers of this parasite—Danilewsky and Ziemann—believed the host-cell to be a leucocyte (hence the name), but Laveran has shown that it is a red corpuscle.

We now come to a group of parasites of great practical importance, the *Babesias,*

formerly called *Piroplasma,* which are the cause of Texas fever or red-water fever, malignant jaundice, East Coast fever, and biliary fever amongst domestic animals. We know, again, little that is certain concerning this group, except that they are unpigmented parasites of the red corpuscles, and are carried by ticks. They are the most destructive to the blood of any we know. In an ox, I have seen the red corpuscles decrease from 8,000,000—the normal—to 56,000 per cubic millimeter in two days.

Another important group, the *Leishmania,* is still uncertain of its exact position. In the body they occur as small bodies with a nucleus and micro-nucleus, but when cultivated on artificial media they become flagellated organisms of a herpetotomas type. It is not quite certain what insect plays the part of carrier, but the different varieties of this group cause the diseases known as Kala Azar or tropical splenomegaly, Oriental sore, Delhi boil, Biskra boil, etc., and also infantile splenic anemia.

The last class are the Hæmogregarines. These are parasites of the red corpuscles of reptiles principally, but they have been described in mammals and birds. We only know certain stages of the greater part of them; they are large, sausage-shaped bodies, not pigmented, and they are supposed to be carried by leeches, ticks, lice and fleas. They generally have a capsule. In some instances the host-cell is enormously enlarged and entirely dehemoglobinized, but in most cases the host-cell is not enlarged.

I have now taken you over some examples of all the known types of blood-parasites, but, at best, the picture in your minds must be like that of a landscape taken from a railway carriage at full speed; and the result, I fear, only a kind of clarified confusion, but it will be something if I have succeeded in making it transparent at the edges. What must have struck you most is the smallness of our exact knowledge of many of these extraordinary organisms and the gaps that there are even in this. But the incitement to future work lies in this fact, for

Things won are done, joy's soul lies in the doing.

Henry George Plummer

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## *SOME EDUCATIONAL PROBLEMS IN KANSAS*[1]

Kansas partakes of the general educational life of our country and confronts in a large measure the problems presented in all other parts of the United States. Much criticism has been directed against public schools, whether common schools, high schools or colleges and universities. Part of this criticism has been constructive in its aim and founded upon a conscientious loyal purpose. Some of its has been destructive, without adequate basis, and founded upon ignorance or unworthy motives. The conditions that subject the schools to reasonable criticism have been found after investigation to be due not so much to the schools or institutions themselves as to the character of our community life quite beyond the sole control of schools and colleges. This has been true of Kansas and of its institutions of higher education; and the most searching criticism has shown them to be on the whole sound, economical in their management, praiseworthy in their motives and purposes. That there has been waste in education of all degrees there is no doubt, but if we set up the rule that those agencies of life that present waste must be abolished or their fundamental organization and purpose changed, then all the agencies of life must be abolished or their fundamental purpose and organization

[1] Semi-centennial of Kansas State Agricultural College, October 29, 1913.